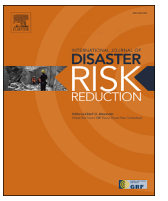
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Assessment of healthcare buildings in terms of spatial requirements in disaster cases together with healthcare professionals: Adana city hospital emergency department during the Covid-19 pandemic

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ABSTRACT

From the past to the present, various pandemics have affected societies to varying degrees, leading to changes in various fields such as social, cultural, and architectural aspects. In this context, the study examines the specific arrangements for the COVID-19 pandemic in the emergency department of a city hospital, conducted in January 2022. The aim is to develop a methodology for questioning the emergency department based on evidence and experience regarding flexibility, spatial adequacy, space organization, and isolation in extraordinary situations such as pandemics and to provide design input for the future. For this purpose, a questionnaire form and a space evaluation form were created. In order to benefit from field experiences, a survey form was administered to 137 healthcare professionals working in the emergency department who are directly affected by spatial design. The authors, who are architects, evaluated the space of the emergency department by filling out the "space evaluation form." The findings were evaluated comparatively.

The study found that the emergency department's spatial performance was adequate in terms of evaluations related to flexibility, spatial adequacy, and spatial organization but inadequate in terms of evaluations related to isolation. The design elements causing this situation were discussed. The aim is that the findings obtained will be data for hospital managers and designers in the design of future emergency services and the organization of existing emergency services.

1. Introduction

Establishing the right user-designer relationship in building types with complex and important use relationships, such as healthcare buildings, has been a focus of research for a long time [1,2]. Communication-based design, multi-stakeholder design, evidence-based design, and experience-based design, as well as information/evidence from the environment and building users, are important, especially for healthcare buildings. Lundin states that intuition and experiential knowledge are very important for healing architecture and can be obtained from users who experience the architectural work [3]. The transfer of knowledge obtained from user groups to the architectural work of the designer forms the basis of experience-based design [4]. Accordingly, the use of experience-based information obtained from the users of the existing building as evidence and information for architectural design and as design input to improve architectural design constitutes a scientific infrastructure. The transformation of experiential knowledge into scientific knowledge as evidence significantly contributes to the literature, especially in applied sciences such as medicine and architecture [5].

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This study was conducted with the foresight that evidence obtained through post-use evaluation of healthcare buildings [6], a complex building type with many design challenges, can enrich and improve the design. In this evaluation, various users must evaluate the structure from different aspects, including the changes that have taken place in the structure [7]. In the literature, satisfaction-oriented research in healthcare buildings has largely been conducted from the patient's perspective. However, spaces directly impact protecting the mental and physical health of healthcare workers, their work efficiency, and motivation [8]. Designing spaces with the right fiction directly affects healthcare workers' work efficiency and job security [9]. Evidence and experience-based design practices are beneficial in preventing infections and reducing stress among healthcare workers [10]. Therefore, it is extremely important that the post-occupancy evaluation of a building type with special requirements, such as a healthcare building, is conducted by healthcare staff.

The recent COVID-19 pandemic has deeply affected healthcare systems globally and forced healthcare structures to adapt to this process [11]. Therefore, the preparedness of healthcare buildings for COVID-19 and similar pandemic situations is critical [12,13]. For today's healthcare architecture, lessons to be learned from the COVID-19 pandemic are expected to have healing effects.

The literature is replete with studies showing that healthcare workers are working under intense stress and experiencing burnout during the pandemic period [14–16]. However, there is evidence that increased stress and anxiety negatively affect work performance [17]. In a study conducted in an emergency department, Valipoor et al. showed that work environments that reflect efforts to meet the stress management needs of healthcare workers can improve their sense of being valued and their sense of professional worth [18]. In addition, some studies have shown that spatially appropriate solutions can significantly reduce hospital-acquired infections [19] and improve work stress and healthcare quality [20–23].

For this reason, a study was conducted with healthcare personnel, who are continuous users of healthcare structures and work under high risk, based on their experiences during the COVID-19 pandemic. The emergency department, which is critical to protecting the population's health during the pandemic and is where the first contact with the patient occurs, was selected as the study area. Our goal is to obtain experience-based data from emergency department healthcare professionals on the front lines during the pandemic. It is aimed to consider this information in the organization of the emergency service in pandemic situations with Covid and similar characteristics, in the design of the emergency service for the future, and the improvement of existing emergency services as a contribution to the literature. For this purpose, the authors prepared a space evaluation form for the architectural evaluation of the emergency room spaces and a questionnaire form to obtain the space evaluations of the health care personnel, the user group directly affected by the emergency room spaces, and applied them in the study area.

As a result of the study, the spatial performance of the emergency department during the Covid 19 pandemic was examined in the context of “isolation, flexibility, spatial adequacy, and spatial organization” parameters by communicating with the health personnel, who are the permanent users of the emergency department we examined, and evidence-based on experience was obtained. We aim to consider the information obtained by analyzing the data obtained from hospital managers and designers in the design of new hospitals with similar capacities and in the improvements and arrangements to be made in the emergency departments of existing hospitals.

2. Background of the research

2.1. Covid-19 outbreak and emergency service

Pandemic periods have caused many changes throughout history, including office spaces, residences, and other spaces related to social life. Especially in these processes, health structures have been of great importance in emergency and crisis management. In this context, the COVID-19 pandemic has deeply affected health systems globally. In some countries, such as Italy, the number of patients far exceeded hospital capacity, leading to collapse [24]. For this reason, the critical increase in the number of patients has forced healthcare organizations to quickly adapt to urgent solutions and make various transformations and arrangements for hospitals to respond to the rapidly increasing demand for services [11]. Temporary field hospitals have been set up in many countries. In some countries, such as China, epidemic hospitals (Leishenshan and Huoshenshan hospitals) have been built quickly [25,26].

In particular, the arrangements and transformations made in hospital structures, infection prevention, and control measures were carried out to protect healthcare workers. Although it is known that the risk is high in all hospitals, healthcare workers in units such as ICU (Intensive Care Unit) and ED (Emergency Department) are at high risk due to their direct and prolonged contact with patients. Many studies have shown that healthcare workers are directly affected physically and psychologically by hospital design and that their rates of epidemics are significantly higher than the rest of the population [9,27–29].

The emergency department is critical to protecting the population's health during epidemics and disasters [30,31]. The ED is the gateway for patients to enter the hospital and is often the first point of contact with the hospital and healthcare personnel for patients who have not been diagnosed with a disease. In this regard, it is very important to protect the health of healthcare workers and other patients, especially during epidemics, and to ensure early intervention. In their study, Marmo et al. summarize the measures and regulations implemented in emergency departments in many countries as follows: syndromic surveillance at the entrance of the emergency department, educational banners and posters, isolation of suspected cases, creation of special COVID areas and units, organization of fever screening areas, identification of different risk areas, separate flows for suspected and confirmed cases, separate pathways and entrances for staff and patients, increasing the number of beds, PPE donning and doffing areas, improved environmental hygiene, etc. [32].

In response to this emerging situation, various studies shared countries' experiences, discussed design principles, and proposed recommendations for healthcare facilities, especially emergency departments [11,33,34–36]. All these experiences and discussions contribute to the analysis of existing structures, their improvement, and the design of new facilities.

2.2. Design principles that become important during the pandemic process

The responses of healthcare buildings, especially emergency services, to epidemics (plague, cholera, influenza epidemics, etc.) have shaped building designs and design principles that change over time [34,37,38]. In this context, sharing experiences between countries has been instrumental in drawing the necessary lessons and taking the right actions. The role and importance of architecture in preventing hospital-acquired infections has become a focus of research. Capolongo and colleagues identified ten design principles for a resilient pandemic hospital [11]. These strategies are discussed for existing structures and for structures to be rebuilt. Sharing such experiences is important to learning the necessary lessons and taking the right precautions. In this context, the study evaluates "spatial adequacy and spatial organization", which determines the structure of the hospital, the patient- and staff-oriented response to functions and transitions between functions, and "isolation" to protect both healthcare personnel, patients and their relatives against unknown risks (infection, infectious diseases), within the parameters of "flexibility" in cases where rapid response is required in disaster and epidemic situations.

2.2.1. Space adequacy and space organization in healthcare buildings

The design of healthcare structures should take into account that healthcare workers and patients are always at risk from infectious agents in units where the workflow is continuous and intense, such as the emergency room. When designing the relationship between units, the design of the units themselves, the flow paths, the furniture and surface materials, the risk of contamination with body fluids and even droplets should always be taken into account during intense work tempos [9,11,34,39–41]. In line with all these sensitivities, inquiries have been made regarding spatial adequacy and organization to ensure the appropriate size and organization in healthy structures.

2.2.2. Concept of isolation in healthcare buildings

Isolation is a protective measure and includes the measures taken to protect patients, their relatives and visitors, and healthcare workers from infectious agents, especially during epidemic periods. In this context, isolation measures should be an integral part of the architectural design process [34,42,43]. In the case of respiratory-transmitted diseases, ventilation systems are very important to protect other patients and healthcare workers [44]. The establishment of fever screening areas/prior triage in emergency services has played an effective role in reducing crowding and preventing infection [35–45]. In addition, distance requirements between patients-visitors-healthcare workers, PPE dressing areas, hygiene and information points, surveillance areas, entrance-waiting-triage relationships, pre-triage areas are the spatial requirements of the isolation parameter [46]. In this context, the precautions that should be taken for infection protection and control purposes have been evaluated as requirements to ensure isolation.

2.2.3. Flexible design in healthcare buildings

Health structures need to be developed for reasons such as medical technology, service delivery models, changing conditions for health care financing, health system organization, and disease development. For this reason, healthcare structures must be designed in such a way as to be flexible and adaptable [47]. The frequency and degree of change are greater in hospitals than in any other structure. In the face of changing needs, hospital buildings must be functional to meet today's requirements and flexible to achieve optimal harmony between function and building in the face of future growth and change [48]. The flexible design of the building means that it is designed by anticipating the future, that is, uncertainty. It is very difficult to predict the future, especially in a field such as medicine, where development is very rapid. However, some structural approaches and classifications for flexible structures have been proposed by various researchers [49,50]. The concept of flexibility has been classified into two approaches in terms of duration and temporality. Operational flexibility is quick, cheap, and reversible. Strategic flexibility is slow, costly, and permanent.

Different professional groups understand the definitions of flexibility principles differently [20,51]. However, some researchers define flexibility for hospital structures in terms of "adaptability," "transformability," and "extensibility" [49,52,53]. Adaptability, or in other words, flexibility of adaptation, is the ability of the healthcare institution to respond to the changing needs of healthcare services without serious intervention. Transformability refers to transforming the structure into a form that can respond to the changing needs in health services with a moderate change in the existing structure. The expandability aspect is the long-term flexibility characteristic that allows the building to expand horizontally or vertically with construction activities to meet the permanently increasing needs of the building [20,49,52,53].

3. Research methods

The emergency department of Adana City Training and Research Hospital (ACTRH) in Turkey, one of the city hospitals that can provide high patient capacity and is integrated into the health care system as a tertiary hospital model, was selected as the study area in the research. In the research, the medical staff of the emergency service of ACTRH was studied to benefit from the field experience. Healthcare personnel (doctors, nurses, health officers) are the user group in direct contact with the patient, fighting on the front lines of the pandemic and directly affected by the design of the spaces.

The structure of the study aims to transform user evaluation into design input by considering the principles of communication-based design, multi-stakeholder design, evidence-based design, and experience-based design. In order to collect data in the research, literature review, observation and measurement, survey, and face-to-face interview methods were used. The research steps were planned as shown in Fig. 1. The permission to collect the study data was obtained from Adana Provincial Health Directorate and Cukurova University Ethics Committee for Scientific Research and Publication, and these procedures were followed.

Literature review: The literature review was made by examining the contents mentioned in Fig. 1.

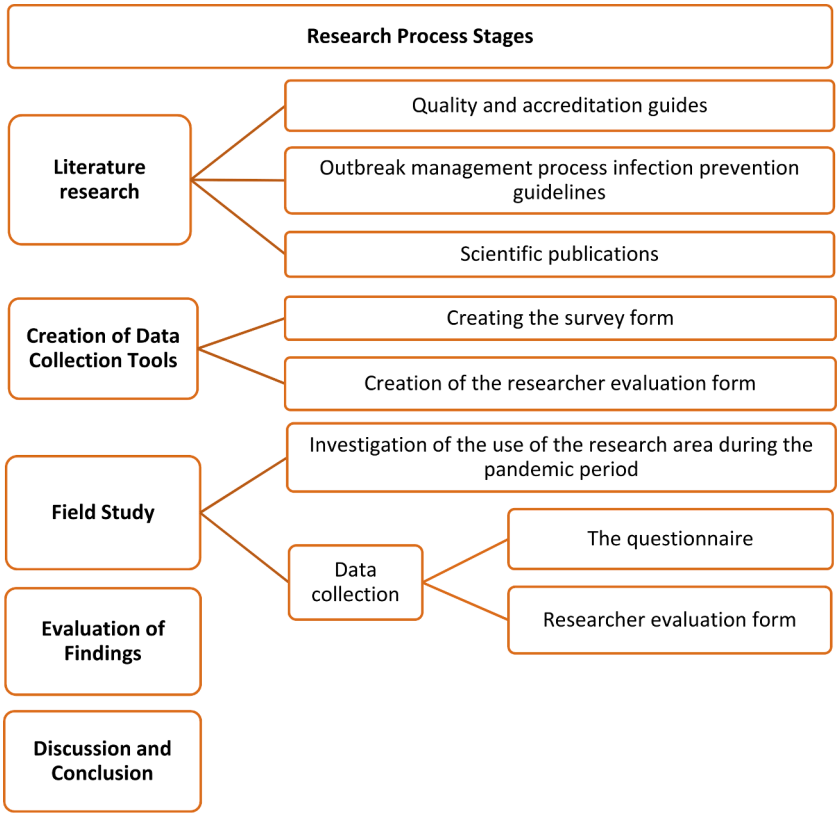


Fig. 1. Research process stage.

***Observation and measurement*:** The space evaluation form, prepared by the authors, who are architects, as a result of the necessary literature research, was filled out by making the necessary observations and measurements in the emergency department. This form was created by researchers to question the adaptation of the spatial features of the emergency department to the epidemic period. During the creation of the form, the temporary self-assessment guide "Infection Prevention and Control Healthcare Facility Response for COVID-19″ was used by the WHO to check the compliance of secondary and tertiary healthcare facilities with the pandemic process [46]. Within the framework of the study, the spatial/architectural requirements of the guide suitable for the emergency department were identified by the authors and simplified for ease of application. In this regard, a checklist was created, and evaluations were made through observation and measurement in the ED as a space evaluation form. This form was created in accordance with the criteria shown in Fig. 2, and the answers met scored as 3 points. Partially met; scored as 2 points; did not meet; scored as 1 point. It is possible to use the form as a self-assessment tool to test infection control and personnel safety in the emergency department in the event of disasters or epidemics that may occur at different times.

Questionnaire: The authors prepared a questionnaire for the spatial evaluation of the emergency department. For this purpose, a survey was conducted among healthcare personnel working in the emergency department, which was the first point of contact during the pandemic, to obtain experience-based evidence. The survey targeted all medical staff, a total of 197 people (security, cleaning, and technical services were not included). The survey form, created using Google Forms, was sent to all staff via the work communication groups, with reminders at various intervals. In the end, 137 employees participated. Survey data was collected between January 1–14, 2022.

The survey form was applied to healthcare personnel who are regular users of the emergency department and have experienced all spatial arrangements, was classified into three groups as design principle evaluation parameters that gained importance during the epidemic period. These evaluation parameters were determined as spatial adequacy and spatial organization, isolation and flexibility parameters. The questions created for the evaluation parameters are grouped as shown in Figs. 3–5. The questions created according to these principles were prepared using a 5-point Likert evaluation. Answers to questions scored as follows: Strongly Disagree: 1 point, … Strongly Agree: 5 points.

The prepared survey form was applied to 50 healthcare workers in the emergency department of another hospital, tested for comprehensibility of the questions, and renewed according to the feedback. An open space was left under each section for the participants to express their opinions and suggestions. It is left to the initiative of the participants to express their opinions and suggestions.

The data obtained from the survey were analyzed using the SPSS 25 program. Frequencies, percentages, and arithmetic averages of the answers to the questions were used in the evaluation. When the data were distributed normally, an independent variable *t*-test and one-way ANOVA were used, and when the data were not homogenously distributed, Games Howel and Welch tests were applied.

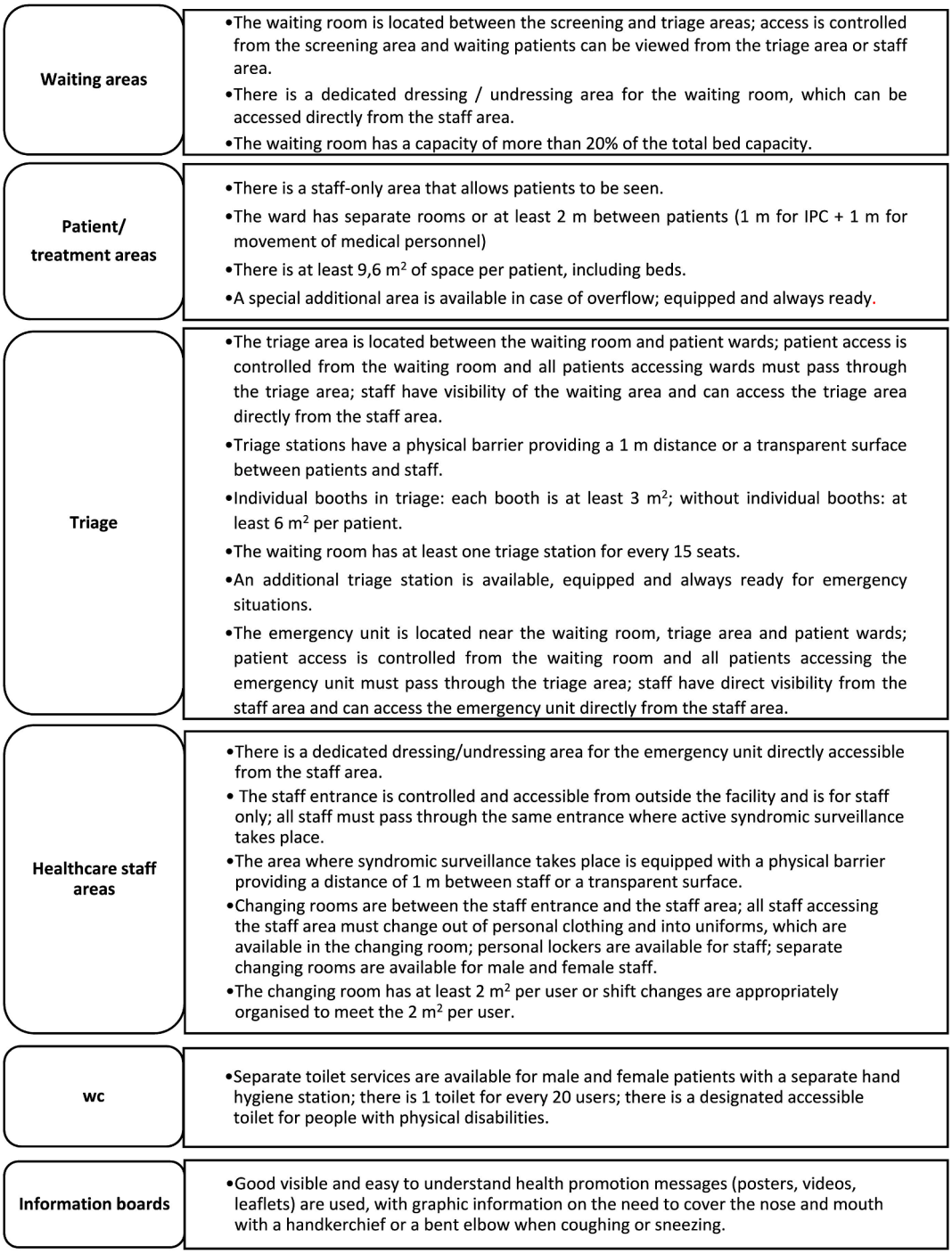


Fig. 2. Architectural evaluation form.

The significance level was accepted as $p < 0.05$. When interpreting the averages of the answers, it was assumed that the answers were equally distributed. Accordingly, Tekin's formula "range width = (array width)/(number of groups to be made)" was used to determine the levels of "meets the need" or " it is sufficient," and the range width was found to be 0.8 (Table 1) [54].

Open-ended questions were added at the end of the questionnaire so the participants could express their opinions, suggestions, and complaints. This field was optional to be filled in. What was written in the open-ended fields was separated according to whether there was a spatial evaluation. Suggestions and complaints about the space were listed and evaluated together with other findings.

***Face-to-face meeting*:** In January 2022, face-to-face meetings were held in the emergency department with the two specialist doctors and the nurse in charge, who played an active role in the pandemic process, to obtain information about the service use

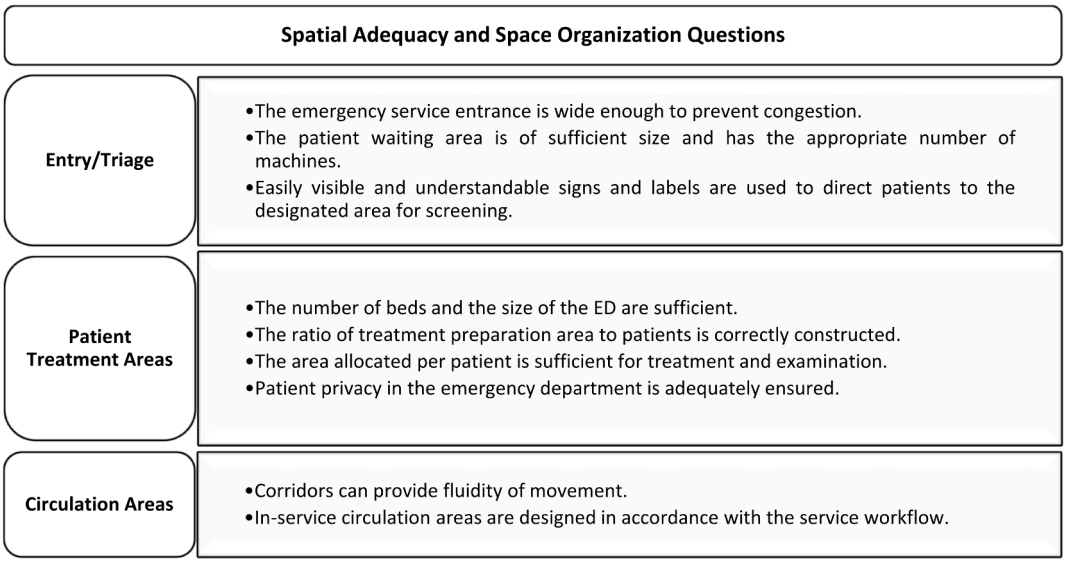


Fig. 3. Evaluation criteria regarding spatial adequacy and space organization.

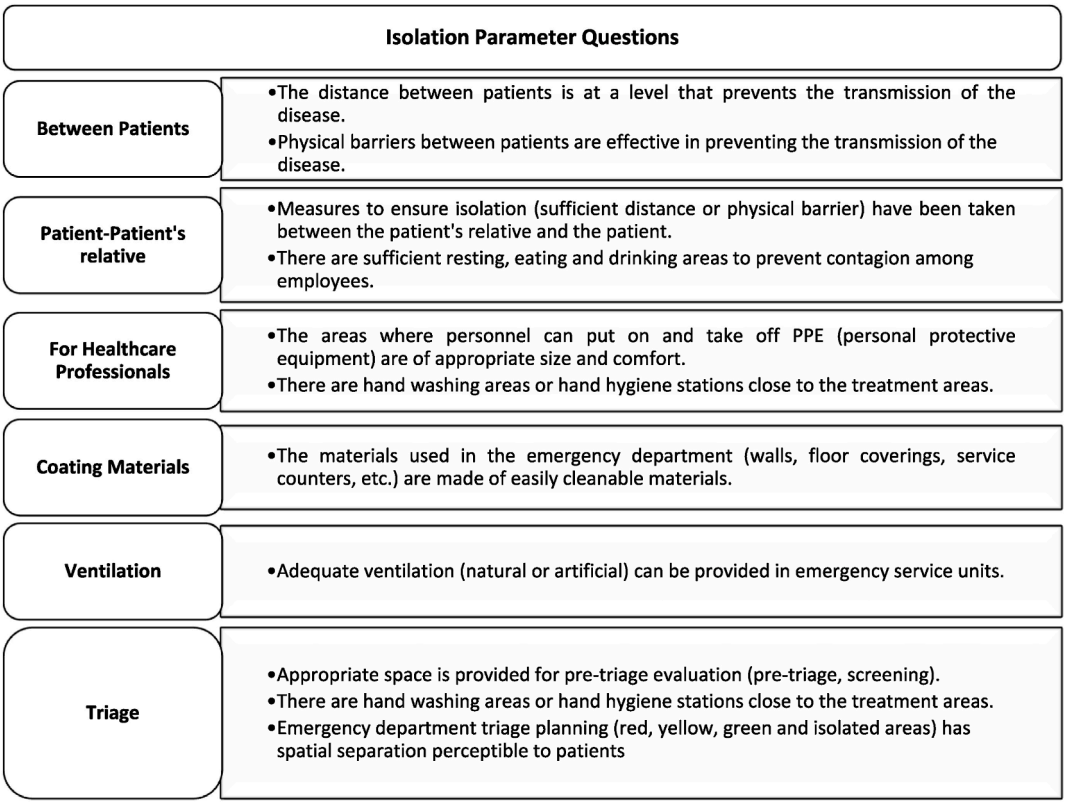


Fig. 4. Evaluation criteria regarding the isolation parameter.

during and before the pandemic period and all the arrangements made. To understand the transformation that took place according to the information received, a chart of the use of the emergency department during and before the COVID period was created.

3.1. Study area

Adana City Training and Research Hospital, selected as the study area, started its services in September 2017. The hospital, which has a closed construction area of 550,000 m2, has a 184-bed Oncology Hospital, 187-bed Cardiology, and Cardiovascular Hospital,

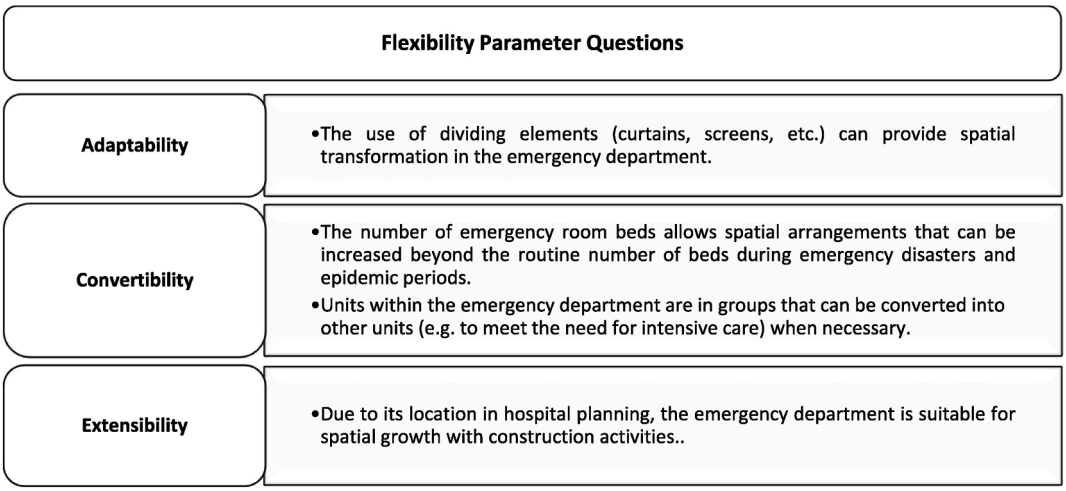


Fig. 5. Evaluation criteria for the flexibility parameter.

Table 1
Evaluation value ranges.

Value Ranges	
1.00–1.80	Very inadequate, very bad
1.81–2.60	Inadequate, bad
2.61–3.40	Medium, neither good nor bad
3.41–4.20	Enough, good
4.21–5.00	Very adequate, very good

347-bed Gynecology and Children's Hospital, 582-bed General Hospital, 100-bed High-Security Forensic Psychiatry Hospital (YGAP), and 150-bed Physical Therapy and Rehabilitation. It is a hospital complex with 1550 beds (Fig. 6).

An average of 35,000 patients per month are expected to use the hospital's emergency department in 2020, and an average of 40,000 patients per month in 2021. The hospital meets a significant portion of the region's healthcare needs. In the pre-COVID-19 pandemic emergency room, the trauma area was designed as patient rooms and consisted of 12 rooms, 1 of which was a negative pressure room. Observation areas are designed as modules with 12-bed sections separated by flexible fabric curtains. The adult emergency department in the pre-COVID period had four active observation modules and a capacity of 48 patient beds (Fig. 7).

According to the interview with the physician and nurse in charge of the emergency department, no additional physical intervention was required during the arrangements made during this period. As schematically shown in Fig. 8, the physical separation of the COVID-19 area in the ED from the rest of the patient area was clearly ensured with the arrangements made.

The area used as the trauma area is reserved for the COVID area, and the area with observation areas is reserved for the other patient area (Fig. 9). The 12 rooms in the trauma area were used as the COVID ICU, doubling the number of beds (Fig. 9a). A total of 24 intensive care beds were made available. The function of this area was transferred to the observation areas (red area). The tomography in the trauma area is reserved for COVID-19 patients, and one of the two resuscitation rooms in the trauma area is reserved for COVID-19 patients. Observation modules were used by doubling the beds to accommodate 24 patients each (Fig. 9b). The total number of beds in this area was 96. This allowed the total number of beds in the ED to be doubled.

4. Results

The sum of the points given in the evaluation of the space evaluation form can be a maximum of 60 (3x20) points and a minimum of 20 (1x20) points. (the scoring method was adapted to be similar to the calculation in the WHO temporary evaluation tool). As a result of the findings, the total score received by the emergency department is 57. In this case, the emergency department was 92.5 % suitable for spatial arrangements to ensure protection from infection. The analyses of the spatial evaluation were evaluated in comparison with the survey questions (Table 2, Table 3, Table 4).

Deficiencies observed during the examinations.

- Although the area allocated for each patient in the observation areas is considered sufficient for the regular use of the emergency department when the number of beds is increased to 2, there needs to be more space for protection against infection and movement of healthcare workers.
- Although there are enough toilets in the observation areas for patients, the number of toilets for patient relatives and staff needs to be increased.

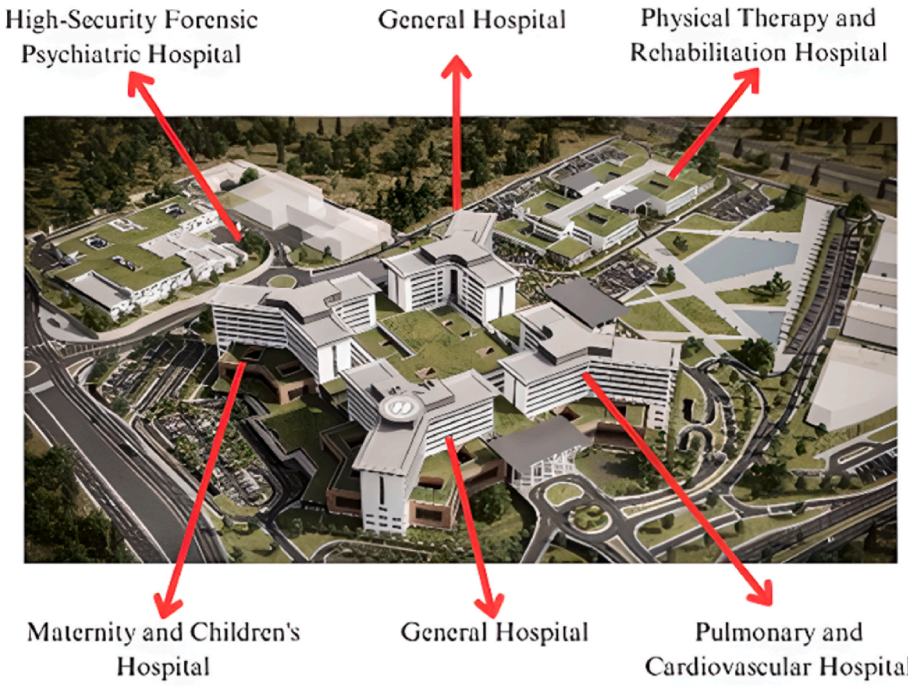


Fig. 6. Adana city training and research hospital (ACTRH), türkiye [55].

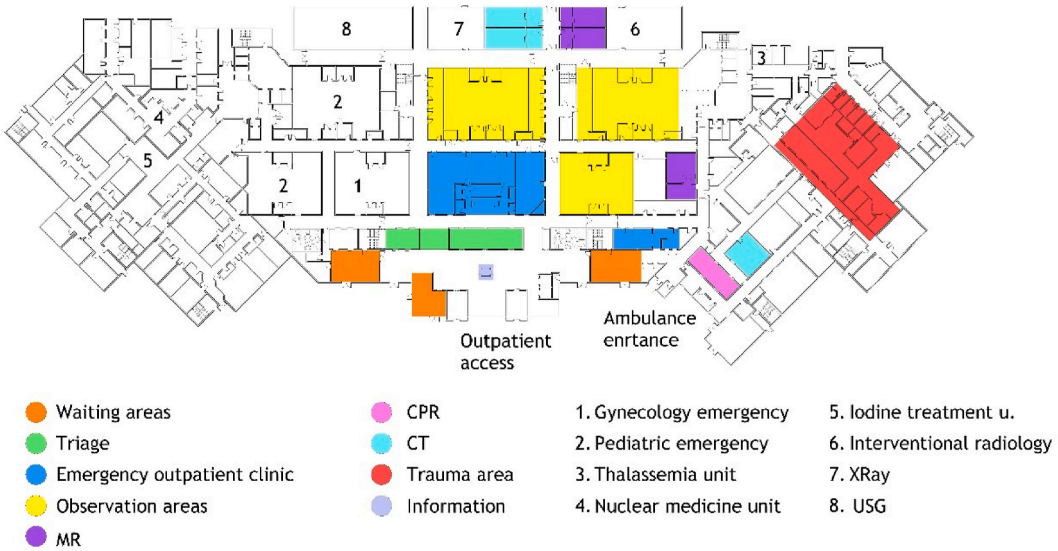


Fig. 7. Emergency department units.

- The adequacy of the flexible curtains used between patients in the observation areas to ensure isolation and patient privacy is an issue that needs to be discussed.

Positive aspects regarding infection prevention and space organization of the emergency department.

- Patient cabins in the trauma arena effectively protected patients and staff from infection and provided appropriate movement space for healthcare personnel, even when the number of beds was increased to 2.
- It was concluded that the relationship and design setup of screening-waiting-triage-staff areas effectively prevent transmission. This planning prevents the patient from reaching the areas without passing through triage. Therefore, triage works effectively.
- The modular design of the observation areas effectively provided isolation between the areas.

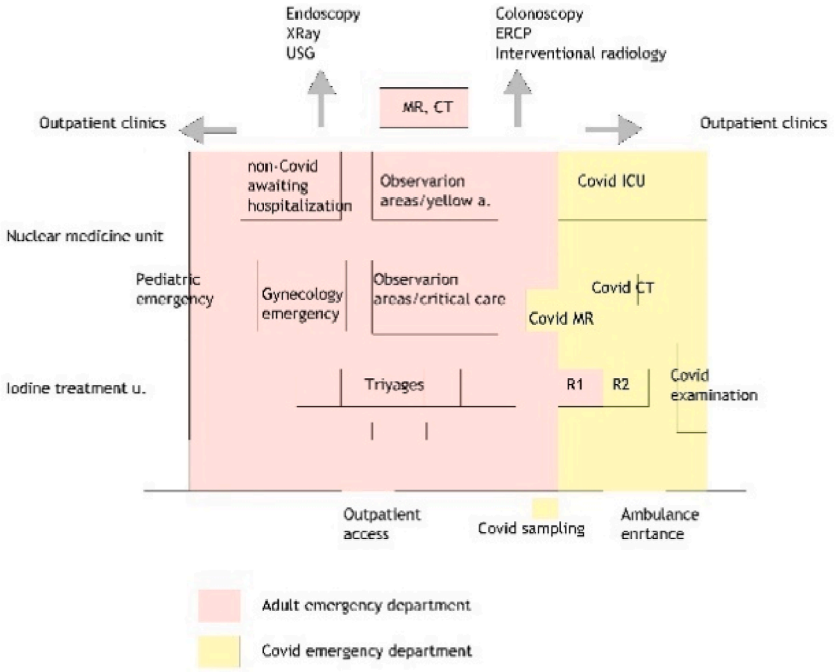


Fig. 8. Use of the emergency department during the COVID-19 pandemic.

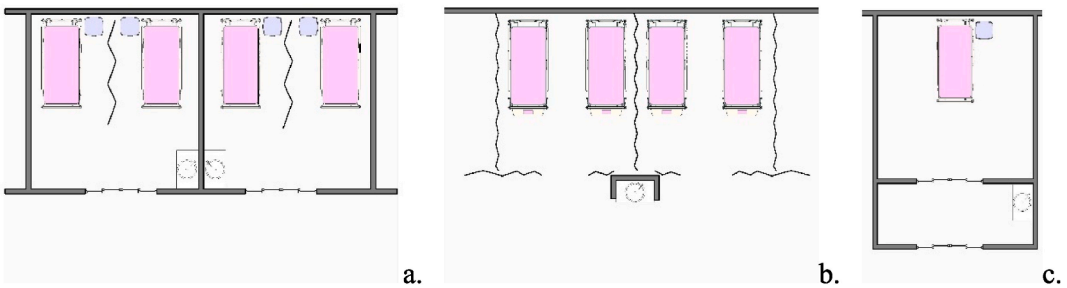


Fig. 9. a. Trauma arena room, b. Observation room, c. Negative pressure isolation room.

The number of health professionals working in the ED eligible to participate in the survey was 197, and 70 % (137 people) participated. The sample's representativeness was 99 %, and the internal consistency of the survey was 91 % according to Cronbach's alpha value. Data regarding the demographic information of the survey participants are shown in Fig. 10.

The emergency department's evaluation in terms of spatial adequacy, spatial organization, isolation, and flexibility, which are the evaluation parameters made by healthcare professionals, is presented below. Then, these findings were compared with the researcher's evaluation and tabulated (Table 2, Table 3, Table 4).

4.1. Findings regarding spatial adequacy and spatial organization

There was no significant difference in the mean responses regarding spatial competence according to gender ($p = 0.508$) and Age ($p = 0.724$) in the independent variable *t*-test, and according to tenure ($p = 0.797$) in the one-way ANOVA test. Since the variances were not homogeneously distributed according to the occupational groups, a significant difference was found in the mean scores for spatial ability according to the Welch test ($p < 0.05$). According to the Games-Howell test, only the group of faculty members showed a significant difference with the other professional groups, while the others did not show a significant difference among themselves (Lecturers n = 3, mean. = 4.55 ± 0.11; Specialist Dr. n = 11, mean. = 3.86 ± 0.65); Research Assistant Dr. n = 43, mean. = 3.55 ± 0.74; Nurse n = 72, mean. = 3.57 ± 0.93; ATT n = 8, mean. = 3.56 ± 0.42).

According to the average scores in the evaluation of spatial adequacy and spatial organization (Fig. 11), the emergency department was found to have sufficient dimensions, and the relationships between the units were rated as “adequate” and “good.” This situation allowed effective service use, especially during the pandemic. However, the flexible fabric curtains used in the observation areas were found to be insufficient to provide visual and auditory privacy for patients. In addition, in cases of exceptional need (for example, when the number of beds in a single cabin is increased to two), the space available per patient in the observation modules is insufficient to prevent staff movement and contagion (Fig. 9 b). In such a situation, flexible partitions must be positioned according to

Table 2
Comparative data analysis of spatial adequacy and space organization parameters.

Spatial Adequacy and Space Organization					
		HCW evaluation (Survey)			Researcher assessment
		Negative n (%)	Neutral n (%)	Positive n (%)	
Entrance/Triage	Entry Dimensions	21 (16)	26 (19)	89 (65)	- The setup of entry units (screening-waiting-triage) is appropriate (Patient flow: Scanning-waiting-triage operates in the order). - Introduction and triage are effective in preventing infection. - Size and organization are appropriate (capacity >60 people.)
	Redirect to screening area	36 (26)	33 (24)	68 (50)	
	Waiting area dimensions and layout	41 (30)	32 (23)	64 (47)	
Circulation	Aisle dimensions and layout	15 (11)	25 (18)	97 (71)	- Corridor widths (3.5 m) are sufficient to provide isolation and flexibility of movement.
	Circulation areas within the unit	26 (19)	30 (22)	81 (59)	- Circulation areas within the unit are designed in accordance with the workflow.
Patient Areas	Number and size of beds	15 (11)	23 (17)	99 (72)	- Dimensions and capacity are sufficient. - Treatment preparation-patient areas setup is appropriate. - The staff desk ensures appropriate distance in patient areas. - Additional areas are ready for use in case of overflow. - Variable per patient area capacity increase! The use of flexible curtains should be considered for patient privacy.
	Treatment preparation	24 (18)	30 (21)	83 (61)	
	Bedside area	32 (23)	22 (16)	83 (61)	
	Patient privacy	42 (31)	22 (16)	73 (53)	

Table 3
Comparative data analysis of isolation parameter.

Isolation Parameter					
		HCW evaluation (Survey)			Researcher assessment
		Negative n (%)	Neutral n (%)	Positive n (%)	
Between patients	Physical barrier	69 (50)	32 (23)	36 (27)	- There is sufficient distance for 2 beds in the trauma arena (10 m2 for 1 patient). - There is not enough distance for 2 beds in the observation areas (for 1 patient 6.25 m2). - The use of flexible fabric curtains as a physical barrier is negative.
	Distance	64 (47)	31 (23)	42 (30)	
Between Patient-visitor arasında	Isolation measures between patient and visitor/companion	59 (43)	39 (29)	39 (28)	- Corridor widths (3.5 m) are sufficient to provide isolation and flexibility of movement. - Circulation areas within the unit are designed in accordance with the workflow (patient bed-treatment preparation-nurse desk).
Between healthcare personnel	Resting, eating and drinking areas	84 (61)	25 (18)	28 (21)	- Hand hygiene points are in sufficient numbers and in suitable locations.
	PPE wearing areas	64 (47)	26 (19)	47 (44)	- Suitable space is provided for PPE. - The number of staff toilets is insufficient.
	Hand hygiene points	10 (7)	21 (15)	106 (78)	- There are dressing and rest areas of appropriate size and comfort for the personnel.
	Staff toilet	62 (45)	16 (12)	59 (43)	- There are elevators (separate entrance) for staff at the entrance.
Triage	Detectable (Triage)	41 (30)	28 (20)	68 (50)	- Triage is identified by color labels along the ground surface. - There is sufficient space in a suitable location for preliminary triage.
	Screening/pre-triage	38 (28)	36 (26)	65 (46)	- Every patient passing into the areas must pass through triage (in bridge position). - Triage rooms have an area of approximately 17 m2 (For 1 patient + staff). - There is an additional triage area available for emergency situations.
Other	Coating Material	12 (10)	38 (28)	85 (62)	- Surface coating materials are standard materials that can be easily cleaned.
	Ventilation	40 (29)	26 (19)	46 (52)	- Mechanical ventilation available, no natural ventilation. Technical measurements were not made.

Table 4
Flexibility parameter comparative data analysis.

Flexibility Parameter					
		HCW evaluation (Survey):			Researcher assessment
		Negative (%)	Neutral (%)	Positive (%)	
Convertibility, adaptability	Modularity	15 (11)	30 (22)	92 (67)	-The paths of those confirmed to have Covid and other patients could be clearly separated.-
	Capacity increase	21 (15)	34 (25)	82 (60)	-The transformation of space modules into each other can be achieved without requiring construction activities.
	Flexible separators	14 (10)	34 (25)	89 (65)	- The trauma area could be converted into a Covid intensive care unit. - The modular structure of the service provides adaptability and convertibility.
Extensibility		21 (15)	44 (32)	72 (53)	- The public space in front of ED is in a position to allow horizontal expansion with construction activities.

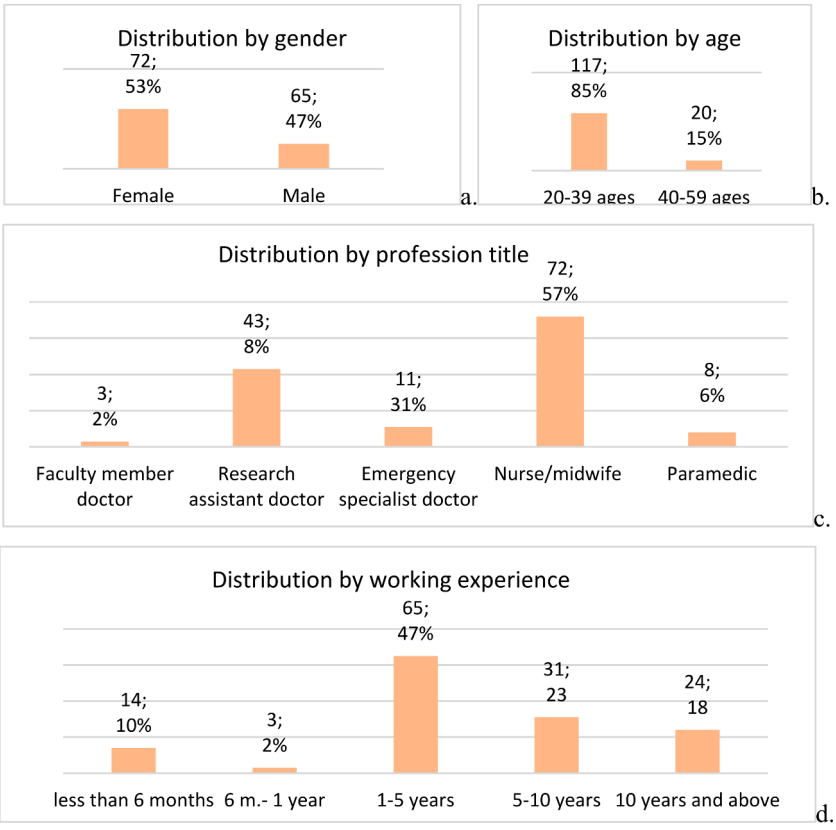


Fig. 10. Demographics of survey respondents (a. Gender, b. Age, c. Job title, d. Employment tenure).

the requirements. Table 2 compares the frequency and percentages of health workers' positive and negative evaluations with the researcher's evaluation.

4.2. Findings regarding the isolation parameter

When examining the responses to the isolation parameter statements, no significant relationship was found between the participants' gender ($p = 0.373$) and Age ($p = 0.188$) and the mean of the responses, according to the independent variable *t*-test. Since the scores were homogeneously distributed by tenure ($p = 0.928$) and professional group ($p = 0.595$), there was no significant difference in the means of the responses according to the one-way ANOVA test ($p < 0.05$).

When the arithmetic mean of the responses to the isolation parameter was examined, the staff eating and drinking areas were rated as “inadequate” (Fig. 12). According to the researcher's evaluation, the resting, eating, and drinking areas for personnel are at a level where a social distance of 1 m can be maintained (Table 3). However, the score on this question indicates that staff do not feel safe protecting themselves from the disease.

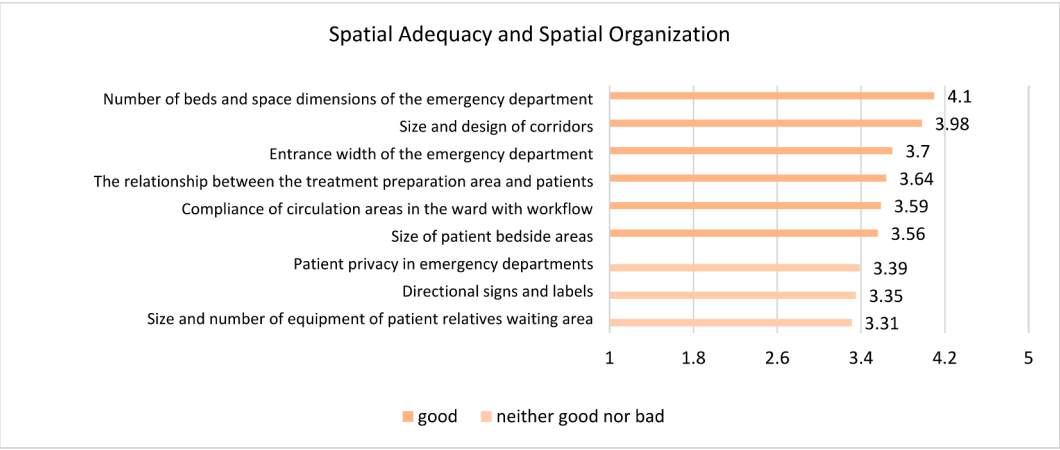


Fig. 11. Averages of responses to spatial adequacy and spatial organization questions.

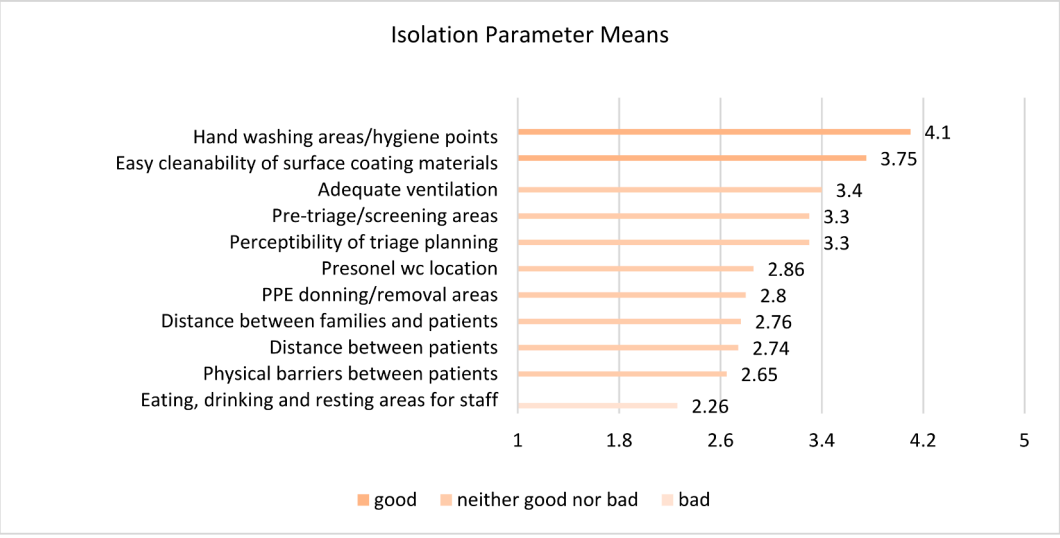


Fig. 12. Mean values of responses to isolation parameter questions.

Hand-washing and hygiene facilities, which are extremely important in preventing hospital-acquired infections, were found to be frequently and easily accessible and considered the ED's most positive aspect. The standard surface covering materials used in hospitals (PVC flooring, glass, steel-aluminum, plastic surfaces, antibacterial wall paints, etc.) were easy to clean. However, the hygienic properties of the flexible fabric curtains used in observation areas were considered an issue to be investigated and discussed.

When the means and frequencies of the responses to the isolation parameter were examined, it was found that the responses had lower mean values than the other parameters (Fig. 12). When the responses were examined, it was concluded that healthcare workers feel they are at risk of infectious diseases.

4.3. Findings on the flexibility parameter

The mean of the responses regarding the flexibility parameter showed a significant difference according to gender in the *t*-test. The mean of men (3.84 ± 0.95) was found to be statistically significantly higher than the mean of women (3.62 ± 0.74) ($p < 0.05$). Since the variances were homogeneously distributed according to occupational groups, the ANOVA test was performed and it was found that there was a significant difference between the means of the responses ($p < 0.05$). According to the Games-Howell test, the means of the faculty members are significantly different from the other groups (Lecturer N = 3, Mean. = 4.75 ± 0.25; Specialist Dr. N = 11, Mean. = 3.45 ± 0.58; Research Assistant Dr., N = 43, Mean. = 3.55 ± 0.76; Nurse, N = 72, Mean. = 3.79 ± 0.94; ATT, N = 8, Mean. = 4.25 ± 0.64). Faculty members rated the structure as more flexible than other employees. The mean of the responses to the flexibility parameter did not differ significantly by age category according to the independent variable *t*-test ($p = 0.215$) and by tenure according to the one-way ANOVA test ($p = 0.696$).

The average of the responses to the flexibility parameter received the highest value, and the flexibility feature was interpreted as "sufficient" or "good" in terms of adaptability, transformability, and extensibility (Fig. 13). The researchers' evaluation also supports this conclusion. It was concluded that this situation was mainly due to the modular design of the emergency department.

As a result of the survey data, the flexibility of the structure (3.74) was evaluated as the most positive parameter among all three parameters. Space organization and spatial adequacy (3.61) and finally the ability to provide isolation (3.08) received the lowest score, respectively (Fig. 14).

The suggestions for spatial requirements from the answers given by health workers to open-ended questions including their suggestions and complaints are as follows;

"*The transition points from examination rooms to observation areas are limited," "It can create a barrier between patients like glass," "More staff rest areas should be created," and "It would be better if there were partitions instead of curtains between patients," "Expanding the areas will increase the number of beds and staff. It needs to be increased", "The space is too much," "The space is sufficient," "The dining hall is too far away*" … As a result of the evaluations, it was seen that there were some problems arising from the physical dimensions of the emergency department. In particular, the long distance between units was cited as a cause of time loss and fatigue for healthcare workers.

5. Discussion

One of the most positive aspects of the hospital's emergency department, which is the study area, is the adaptability and transformability brought by its modular design. However, as mentioned in Ref. [39] the conclusion that the public space provides flexibility to the building by providing expandability was also reached in our study. In fact, in the study area, public spaces at the emergency department entrance and in many hospital buildings were used as fever screening areas [56,57]. Although this structure does not require operational expansion, hospital structures should be designed with future needs in mind. According to our results, flexibility in hospital design was evaluated as a very important principle in our study, as stated in the existing literature [49,51–53,58].

Fabric curtains, widely used in emergency departments, provide flexibility but are controversial regarding privacy (visual and auditory) and isolation. The importance of easy-to-clean surfaces and coating materials during the pandemic is frequently mentioned in the literature [34,59]. Although fabric curtains, which are frequently used in emergency departments, are a subject that should be discussed in detail in other studies, the use of fixed separators will be a very effective material for providing isolation.

The design of the entrance-waiting-triage-patient areas of the ED in which we work is such that patients and other visitors cannot reach the interior corridors without triage. This design has been particularly beneficial during periods of high contamination risk, such as pandemics. There is evidence that triage reduces patient length of stay and emergency department crowding [60–63]. The design of the triage as a barrier between the patient areas and the entrance area will also be effective in preventing the spread of nosocomial infections and other infectious diseases in emergency services. It has been observed that there are not enough studies in the literature that focus on triage design in the ED. Triage design in the emergency department has been identified as a topic that needs to be discussed with comparative examples.

In the emergency department where the study was conducted, a second bed was added to each cubicle to increase the number of patient beds during the pandemic. Although this provided enough space to protect against infection in the larger trauma area, there was not enough space per patient in the observation areas. Although this area is reserved for patients who are not suspected of having

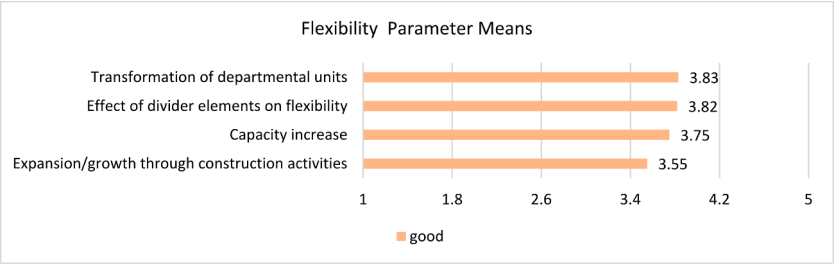


Fig. 13. Mean responses to flexibility questions.

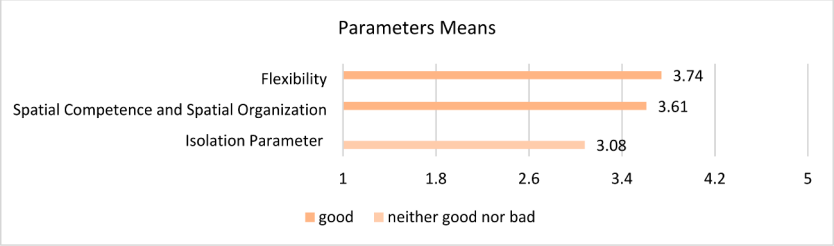


Fig. 14. Mean values of all parameters.

COVID-19, it is a risk for undetected situations. In this case, there is not enough space for the movement of healthcare workers and their protection from infection. Treating patients in single rooms is important to ensure isolation and privacy [64]. The use of single rooms is an ideal option, especially when there is a possibility of contamination [41]. However, using single rooms may not be possible in crisis periods with a sudden increase in patients, as in this study area. For this reason, it has been concluded that the design of the emergency department should be flexible enough to allow sufficient space to protect all cabins from infection, taking into account the situations where the number of patient beds should be increased. An emergency department designed in this way will be able to increase capacity more safely in the face of excessive and sudden increases in patient numbers.

It was observed that patient monitors were monitored from the common nurses' station in the trauma area, which was converted to a COVID ICU in the study area. Ensuring that all patients were monitored at the nurses' station prevented unnecessary staff fatigue and reduced the risk of infection by reducing contact. The International Hospital Federation noted that hospitals were very quick to develop innovative solutions during the COVID period and that this process had many positive contributions [65]. During this period, studies show that technological and innovative solutions reduce crowding and infection risk in hospitals [48,66–69]. We believe that more solutions should be developed with innovative approaches in the field of health care that can reduce risks for extraordinary situations that may arise in the future.

The dimensions and capacity of the building are large; however, it contributes to the emergency department in terms of increased capacity, flexibility, ease of movement, and even isolation, it has been observed that some units are interpreted as “too far,” “too much distance,” or “too large an area”. Due to the dimensions of the building, daylight, and natural air, the importance of which is emphasized in many studies [34,36,64,70,71], were not possible to incorporate into the units of the emergency service. The psychological impact of this situation on healthcare workers under intense working conditions should be questioned. The distance and area dimensions of a building with such capacity and dimensions should be optimized with an appropriate usage matrix in line with the information/evidence obtained from its users during the design or usage process.

Systematic data collection and reporting of infrastructure and other needs to be developed, even from a newly completed hospital structure, extending the strength and life of the structure [72,73]. Of course, the needs and dynamics of each building should be evaluated, and structure-specific solutions and improvements should be proposed. However, units with similar functions face similar issues across healthcare structures, such as hospitals or emergency departments, and can learn from each other. We hope that the results of our evaluation will be questioned and discussed in other emergency services of similar size and planning in Turkey and around the world. We consider the pandemic period an important time for questioning healthcare structures and developing innovative approaches. We believe that the design approaches that we have studied in our research and evaluated their positive and negative aspects will contribute to the literature and design guides as design principles for the future.

5.1. Limitations of this study

Healthcare building design is a type of building that involves quite complex relationships, and the design process is difficult. Obviously, many design principles should be considered in the design process. It is possible to systematically classify and detail these regarding internal organization strategies, building exterior and landscape strategies, energy efficiency and sustainability strategies, and the like. However, the study -COVID-19 pandemic - emergency room interior design parameters and evaluation are limited within the scope of experience-based design.

6. Conclusion

The recent pandemic has shown that, despite these developments in medicine and technology, pandemic diseases can still occur and profoundly impact health systems. In addition to epidemics, health systems and structures must always be prepared for disaster situations and even the feared biological warfare possibilities of the future.

The design of high-risk units such as healthcare buildings and emergency rooms can be extremely effective in preventing infectious diseases and hospital-acquired infections. In order to improve daily routine services and prepare for extraordinary conditions such as pandemics and disasters, it is important to analyze existing structures from the perspective of their users and uncover experience-based knowledge/evidence. The resulting data will be considered in both the improvement of existing structures and the design of new buildings. They will link in the dynamic process of bringing healthcare buildings to a higher level. In our study, the principles of emergency department design were evaluated with their positive and negative aspects during the pandemic period, and it was envisaged that these evaluations - by expanding the scope - would be made for other emergency services as evidence-based information for literature-based emergency department design. The preparation of emergency services for unexpected negative situations that may occur in the future can be achieved through literature-based regulations and the creation of guidelines/plans.

Ensuring multi-stakeholder participation in the design processes of hospital buildings is important, especially in terms of detailed evaluation of medical needs during the design process. In addition, the involvement of architects and designers in the flexible use processes of the hospital for the future will contribute to the efficient use of the building. This requires two-way participation in the design and use process because medical staff and designers are involved.

The results and evaluations we have presented are among the design principles to be considered for the city hospital typology and for the design of other emergency services of similar size and capacity. The evaluation criteria included in the study were developed with the support of the WHO and the scientific literature and have universal values. For this reason, we believe that the evaluation tools developed in the study, as well as the results obtained in this study, will provide data for studies on the transformation of experience into evidence in architecture and hospital design guidelines for healthcare structures regarding the use of the emergency department during the pandemic process.

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Ethics approval and consent to participate

This study was initiated with the approval of Cukurova University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee (Meeting number: 111, Meeting Date: May 21, 2021). Permission was obtained from Adana Provincial Health Directorate Public Hospitals Services Directorate for data collection. This article is derived from a master's thesis written in Cukurova University, Institute of Science, and Department of Architecture (Thesis no: 791818).

CRediT authorship contribution statement

Zeynep Acehan: Writing – review & editing, Writing – original draft, Resources, Methodology, Formal analysis, Conceptualization. **Ozlem Senyigit Sarikaya:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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